AN ECONOMIC EVALUATION OF THE RECENTLY TERMINATED SHEEP LICE ERADICATION CAMPAIGN OF WESTERN AUSTRALIA 1987 – 1993

Neil Thomson, University of Western Australia

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Abstract

The Western Australian Sheep Lice Eradication Campaign was initiated in July 1987 and terminated in June 1993. On a State–wide basis, the prevalence of flocks with a positive Lice Detection Test dropped from 30% in 1987/88 to 23% in 1990/91, however it rose again to 31% in 1991/92 and 38% in 1992/93. Ordinary Least Squares regression analysis suggested that a relationship between sheep lice prevalence and the Wool Price Market Indicator existed. Apart from some small regional effects, the Campaign did not appear to significantly reduce sheep lice prevalence across the State. It is estimated that the costs of the Campaign outweighed the benefits and would continue to do so if the Campaign was extended beyond 1993.

Important issues about the evaluation of pest or disease control programs, highlighted by this program are discussed.

Background

The Sheep Lice Eradication Campaign (SLEC) was initiated in 1987 following an agreement between the Western Australian Farmers Federation, the Pastoralists and Graziers Association and the Department of Agriculture, Western Australia (DAWA). The aim was to eradicate sheep lice from Western Australia by 1996, thereby reducing the use of costly chemical treatments, increase the value of the wool clip and reduce the environmental impact of chemical use.

At the cornerstone of the Campaign was the Lice Detection Test (LDT) which was made compulsory for all wool growers by the Lice Eradication Fund Act (1987). The Campaign was jointly funded by the Department of Agriculture and by wool growers via compulsory grower payments to the Sheep Lice Eradication Fund established in 1987 and renewed in 1992 with the support of grower organisations and the Department of Agriculture.

Benefit cost studies prior to 1992

Prior to 1992 the SLEC was the subject of two internal DAWA benefit cost analyses (Mattinson 1986, Hanna 1989). Most of the early analyses had a very optimistic expectation of future success assuming that eradication would be achieved even in the worst case scenario. This assumption was supported by the "Lice Model" (Hanna 1989) which included a simulation of the spread of sheep lice in WA. The probability of infestation was calculated in the following way.

$$Pi_t = 1\,(1 - kPx_t)^x \,*\, (1 - kPn_t)^n \qquad \text{(i)}$$

where

Pi = probability of infestation
Pt = probability of buying infested sheep
Pn = probability that neighbours' sheep will be infected
k = an adjustment (claimed to simulate transmission)

x = number of trading contacts per farm
n = number of contacts with neighbour
t = time

Assumptions about t and n were made both "with" and "without" the Campaign. The adjustment factor was necessary to stabilise the prediction of prevalence "without" the Campaign over time. The adjustment factor k was set so that Pi "without" the Campaign would be constant (ii) over time ie:

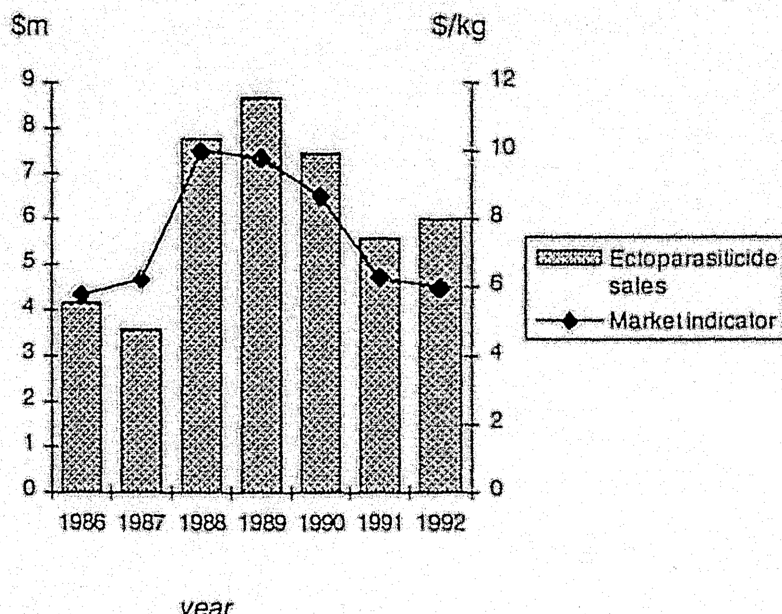
$$k = \frac{d\,Pi}{dt} = 0$$

Predicted sheep lice prevalence "with" and "without" the Campaign was calculated using this model and further assumptions about the probability of detection and treatment efficacy. The spread function (i) assumed that the risk of infestation was the same for all properties. This assumption was made for convenience but may have resulted in either an underestimation or overestimation in the spread of the pest. For example the spread function (i) did not consider the impact of high risk properties (eg. those owned by traders) on spread, that may have acted as nodes of reinfestation throughout the State. The model also assumed that the detection rate of sheep lice would be constant over a range of sheep lice prevalence, the high rate of false positive (25%), the number of false negative (1%) LDT tests and the number of properties excluded from the test in a given year (10%) meant that the predictive value of the test (and therefore the detection rate of lice) was likely be reduced as sheep lice prevalence reduced. The Lice Model also assumed constant treatment efficacy which may not have been true if pesticide resistance was increasing (de Chaneet *et al* 1989, Morcombe *et al* 1994). These reasons may explain why the Lice Model made optimistic predictions about future prevalence even though some of the other assumptions (ie number of neighbour, and trading contacts) may have been reflective of farmer practice.

Trends and explanations 1987 - 1993

In 1987 sheep lice prevalence was estimated to be 35% of flocks in WA after adjusting for the number of tests and the number of false positive and false negative tests. This dropped to 26% by 1990 and then began to rise again to exceed 40% in 1993. Supporters of the Campaign were eager to attribute the early reductions in sheep lice prevalence to its activities as demonstrated by a number of DAWA media releases from 1988 to 1990. They overlooked the dramatic increases in wool prices and ectoparasiticide sales over that period. Examination of ectoparaticide sales data supplied by the National Association for Crop Protection and Animal Health (Avcare) suggests there is a correlation between the price of wool and their total sales.

Figure 1: Total ectoparasiticides sales ($m/annum) and the Wool Price Market Indicator ($/kg) from Jan 1 1986 until Dec 31 1992



One of the perceived benefits of the Campaign was that farmers could avoid routine treatment of lice on the basis of a -ve LDT. It was hoped that this would lead to a reduction in the blanket use of ectoparasiticides. There may have been individual circumstances where the Campaign (or more specifically the LDT) enabled growers to reduce their ectoparasiticide use however this did not appear to have an effect on their aggregate consumption (figure 1).

Regression analysis of ectoparasiticide sales and sheep lice prevalence was limited because ectoparasiticide sales figures were annual, limiting the analysis to 6 observations. Sheep lice prevalence and Wool Price Market Indicator data however, were available quarterly giving a total of 23 observations over 6 years. I therefore tested the hypothesis that the Wool Price Market Indicator would sufficiently explain some of the trends in prevalence with other variables where the data was avaliable (ie seasonal dummies).

A regression model explaining sheep lice prevalence trends

Estimates were made of variables that could explain trends in prevalence using Ordinary Least Squares regression. Diagnostic tests of functional form* and serial correlation** were made on the regression models reflecting several alternative *a priori* hypotheses in order to identify a preferred model on the basis of econometric criteria. Nested and non-nested testing procedures were used to improve the power estimations and reduce the effects of multicollinearity where that appeared justified by diagnostic tests.

The analysis used twenty three observations of quarterly wool bale brand LDT data, starting in 1987Q3 and ending in 1993Q1. Exogenous variables included the Wool Price Market Indicator, seasonal dummy variables (to adjust for seasonal variation between quarters), time trends (to simulate potential underlying changes in prevalence over time) and dummy variables to simulate an apparent structural break near the end of the time series.

The Wool Price Market Indicator was included as an explanatory variable however problems of serial correlation were evident in a model that did not include any lagged effects of the wool market indicator. Serial correlation was reduced to acceptable levels by including market indicator variables lagged sequentially by five quarters.

The regression models were significantly improved by the inclusion of seasonal dummy variables to adjust for the regular variation in prevalence from quarter to quarter relating to the detection and recording of infestations over a financial year.

Biological studies (de Chaneet *et al* 1989, Morcombe *et al* 1994) have identified pesticide resistance and suggest that this may have influenced sheep lice prevalence in WA especially in recent times. When a dummy variable was included for the last 3 or 4 quarters the model was improved (using log likelihood criteria). Various dummy variables and time trends were tested to account for any structural change in the last 12 months and the most statistically acceptable of these (in terms of overall model specification) was a time trend starting in the first quarter of 1992. The acceptability of this time trend may also be explained by other specification errors in the model such as the functional form of the relationship between the Wool Price Market Indicator and sheep lice prevalence.

* *Ramsey RESET tests, Lagrange multiplier (LM) version (Chi Sq) and F version*
Heteroskedasticity test (LM and F)

** *LM test for serial correlation*

The preferred model

$$PR = INPT + a.MI(-2) + b.(MI-3) + c.MI(4) + d.(MI-5) + e.(MI-6) + h.D1 + i.D2 + j.D3 + k.DT + E$$

where

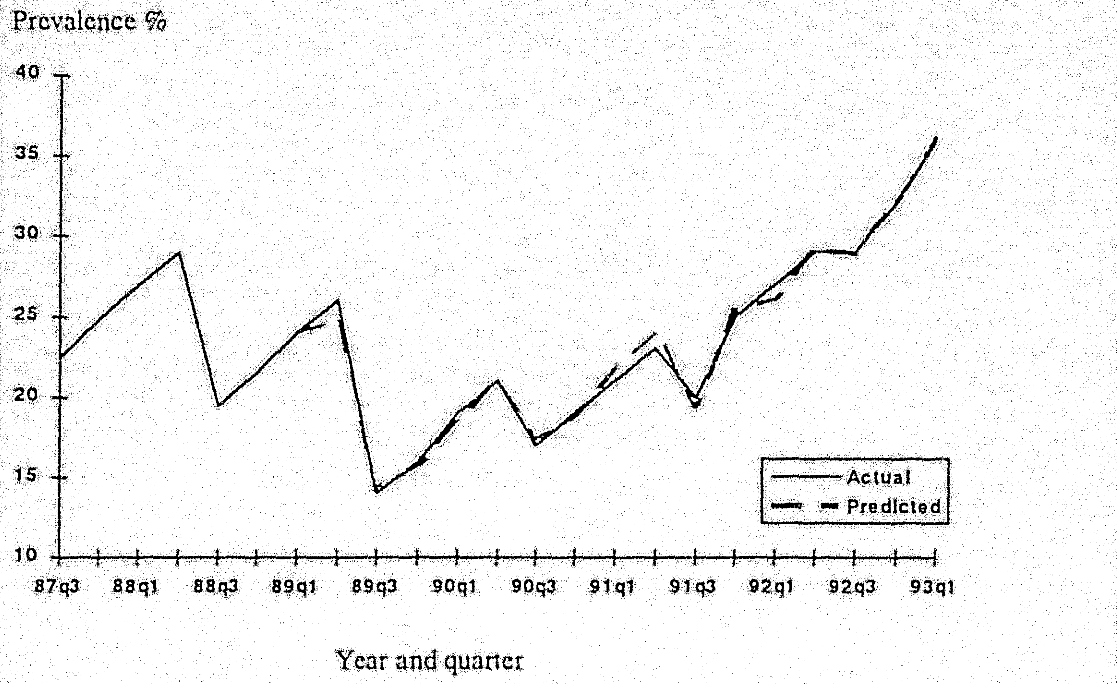
PR = Prevalence as measured by the LDT
INPT is the constant
MI= market indicator for wool
D1 D2 and D3 are seasonal dummies
DT is a dummy time trend starting in the first quarter of 1992
E is the residual

Table 1: Estimates of the preferred and a restricted model

	The preferred model	A restricted form of the preferred model
Variables	*Estimates*	*Estimates*
INPT	43.53**	40.68**
MI(-2)	-0.0084*	-0.0111**
MI(-3)	-0.0039	
MI(-4)	0.0027	
MI(-5)	-0.0154*	-0.0139**
MI(-6)	-0.0024	
D1	0.719	1.727*
D2	2.692*	3.789**
D3	-1.790*	-0.781
DT	2.058*	2.768**
R bar squared	*97%*	*96%*

* denotes significant to 95% confidence limits
** denotes significant to 99% confidence limits

Figure 2: Actual and predicted values of prevalence (%) using the preferred model



Conclusions from regression model estimates

There appears to be strong evidence that sheep lice prevalence in Western Australia is associated with the Wool Price Market Indicator. Analysis suggests that changes in the wool price effect observed lice prevalence within 9 months and that wool price changes continue to influence lice prevalence 21 months or more after that change.

As wool price decreases by one dollar it could be expected that observed lice prevalence would increase by 1.1% within 9 months and that it could increase by a further 1.4% within 21 months all other things being equal. These changes wou'd only apply to wool prices within the bounds observed since 1987Q3. It also appears that further increases in observed prevalence of up to 8% may have occurred in the last 3 quarters. There was no statistical evidence of any campaign effect in any given year or over the whole campaign.

Benefits may have been observed by regional analysis

Regional sheep lice prevalence data was examined and no significant departure from the aggregate data was discovered. The only statistical evidence that suggest that the Campaign may have had some regional effects was the results from Katanning suggesting that increase in the percentage of tests that showed 2 or more lice bodies (2+ tests) in the last 2 years were suppressed when compared with the increases observed in other regions (DAWA 1993). This data set was made up of annual observations so the estimates could be easily overturned by changes in the simple model structure.

If it is assumed that i) the campaign was responsible for this suppression of 2+ tests and ii) the proportional change in the 2+ detections corresponded to the same proportional change in heavy infestations and iii) estimates that suggested heavy infestations affected 12% of infested flocks and iv) the losses to these heavily infested flocks were approximately $2.60 per hd (Thomson 1992) then farmers would have benefited by $70,000 in 1991 and $190,000 in 1992. This compares with an annual campaign cost between $1,600,000 and $1,900,000.

Assessment of future benefits and costs at the time of termination

Prior to its termination the Campaign was subjected to further benefit cost analyses. These were calculated using the Pest Control Evaluation Spreadsheet, PCES (Thomson and Young 1993) similar to the Research Evaluation Spreadsheet, REVS of DAWA but adapted for pests (Morrison 1991).

The PCES framework requires assumptions about the extent and rate of the spread of the pest and on-farm losses of that pest. Unlike the Lice Model (Hanna 1989) this evaluation did not attempt to simulate the spread of the pest. The effect of reductions in prevalence (with and without the Campaign) on the net present value (NPV), internal rate of return (IRR) and the benefit cost ratio (BCR) of the Campaign were tested.

The NPV of the Campaign was highly sensitive to the assumed spread "with" and "without" the Campaign. Some sensitivity analyses are presented in table 2 which demonstrate the sensitivity of benefits to the assumed prevalence of sheep lice.

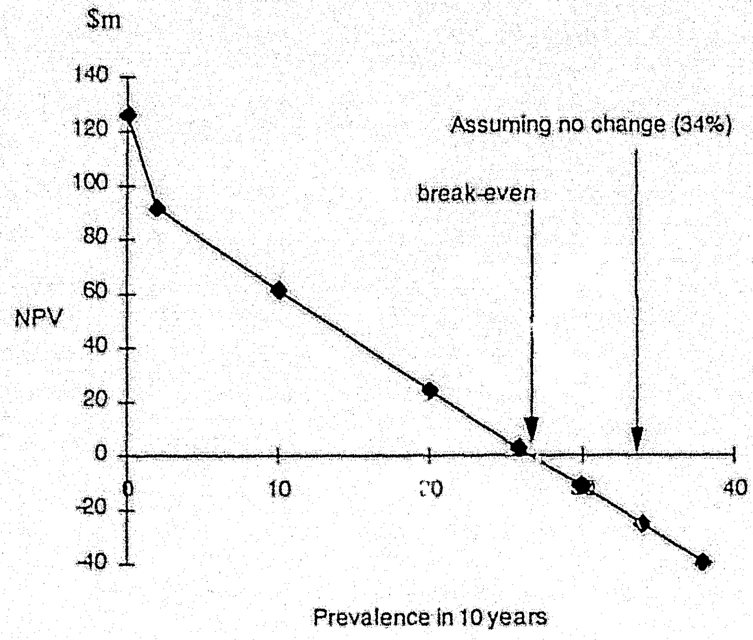
Table 2: Results of sensitivity analysis

Prevalence after 10 years with the Campaign	Prevalence after 10 years without the Campaign	NPV	IRR	BCR
38%	34%	-$39m	-ve	-0.6
34%	34%	-$25m	-ve	0
26%	34%	$3m	10%	1.1
0%	34%	$126m	85%	9.4

Key assumptions

- Prevalence without the Campaign would remain at 34%
- Discount rate is 7%
- Wool price is $6.50 over the next 30 years
- Average losses per head of flock infested $0.98/hd. (both light and heavy infestations).
- The Campaign costs are $1.9m per year
- Total sales of ectoparasiticides attributed to lice control is $4m per year

Figure 3: NPV of the Campaign vs sheep lice prevalence achieved in 10 years



Prevalence had to be reduced by at least 7 percentage points within 10 years (eg from 34% to 27%) if the Campaign was to break-even in the long run. On the basis of past performance there was no empirical evidence to support the view that this would occur. This was one of the major considerations when the Campaign review group (DAWA 1993) recommended its termination. Major improvements to the success of the Campaign both at a regional and State level would be required to achieve break-even. The Campaign needed to demonstrate benefits greater than break-even to sustain continued industry support . In June 1993 the grower levy was terminated and State funds were redirected into a general ectoparasite research program administered by DAWA.

Conclusions

The evaluation of the SLEC highlighted the value of *ex post* econometric analysis, the dangers of simulation without empirical support, the dangers of making simple assumptions about a static "without" scenario, and the importance of considering other potential exogenous variables when assessing the progress of a program. The estimated benefits of pest control programs are often highly sensitive to the proportion of observed gains or losses that are attributed to it.

In hindsight the Lice Model appeared too simplistic and too sensitive to uncertain assumptions to produce meaningful estimates of the benefits of the Campaign. The later evaluations of SLEC demonstrated the value of simple econometric analyses of observed data. This approach would have been strengthened with some small changes to the type of analysis and data collected. For instance, a cross sectional analysis (using shire or district data) would probably have been useful in monitoring the response of prevalence to campaign effort in the early stages of the Campaign. The analysis of trends was made difficult by the level of data aggregation early in the Campaign.

Apart from some small regional effects the Sheep Lice Eradication Campaign did not appear to effect sheep lice prevalence in WA. Other factors such as the Wool Price Market Indicator appeared to affect sheep lice prevalence. There was also some indication of a structural change in the regression model that may have been a result of increasing pesticide resistance although this observed change could equally be attributed to a number of other factors, including model mis-specification.

On the basis of observations made up until mid 1993 it was estimated that costs outweighed benefits and would probably continue to do so if the Campaign continued.

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